

# Partnering Science and Engineering: Lessons from Chandra for IXO

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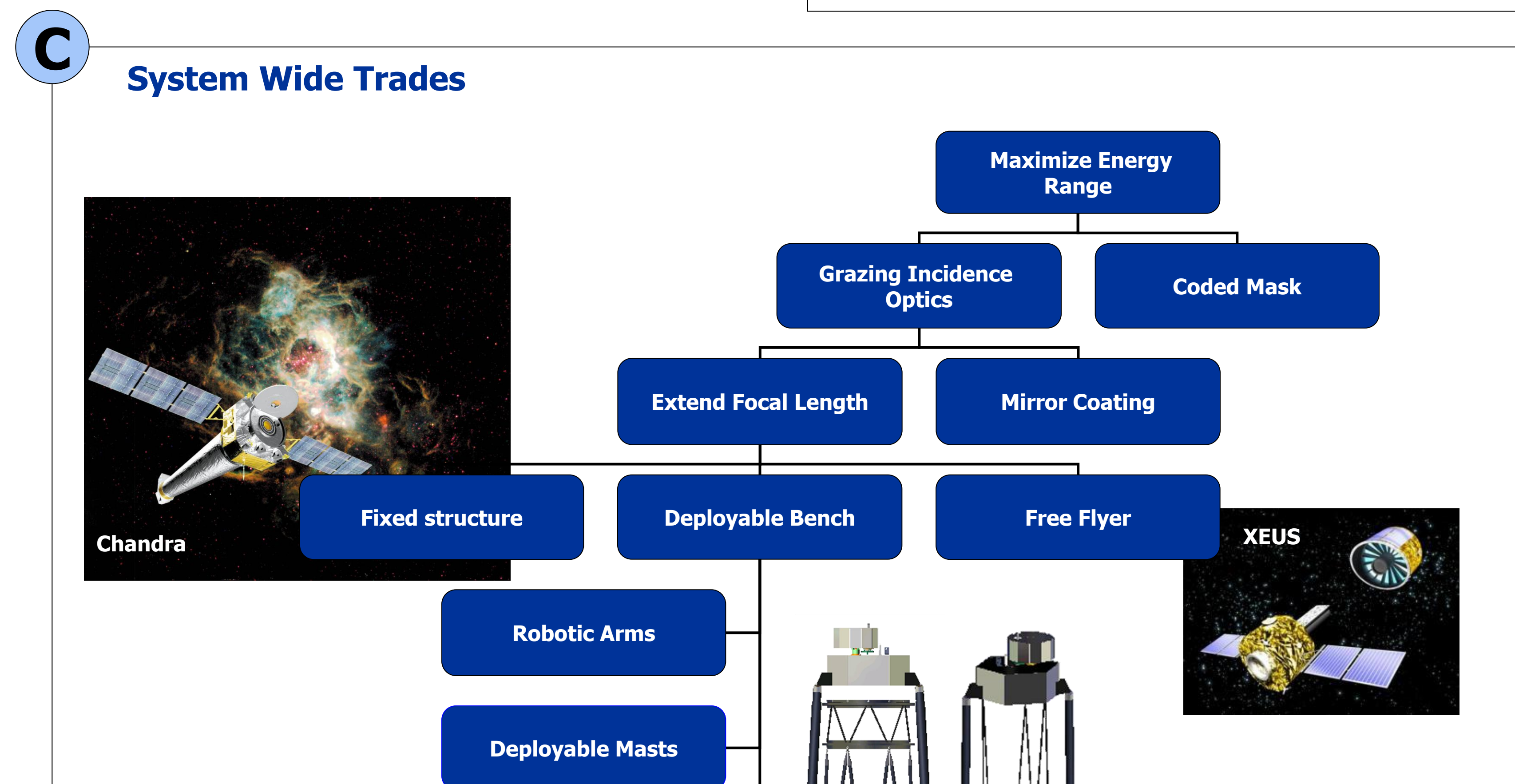
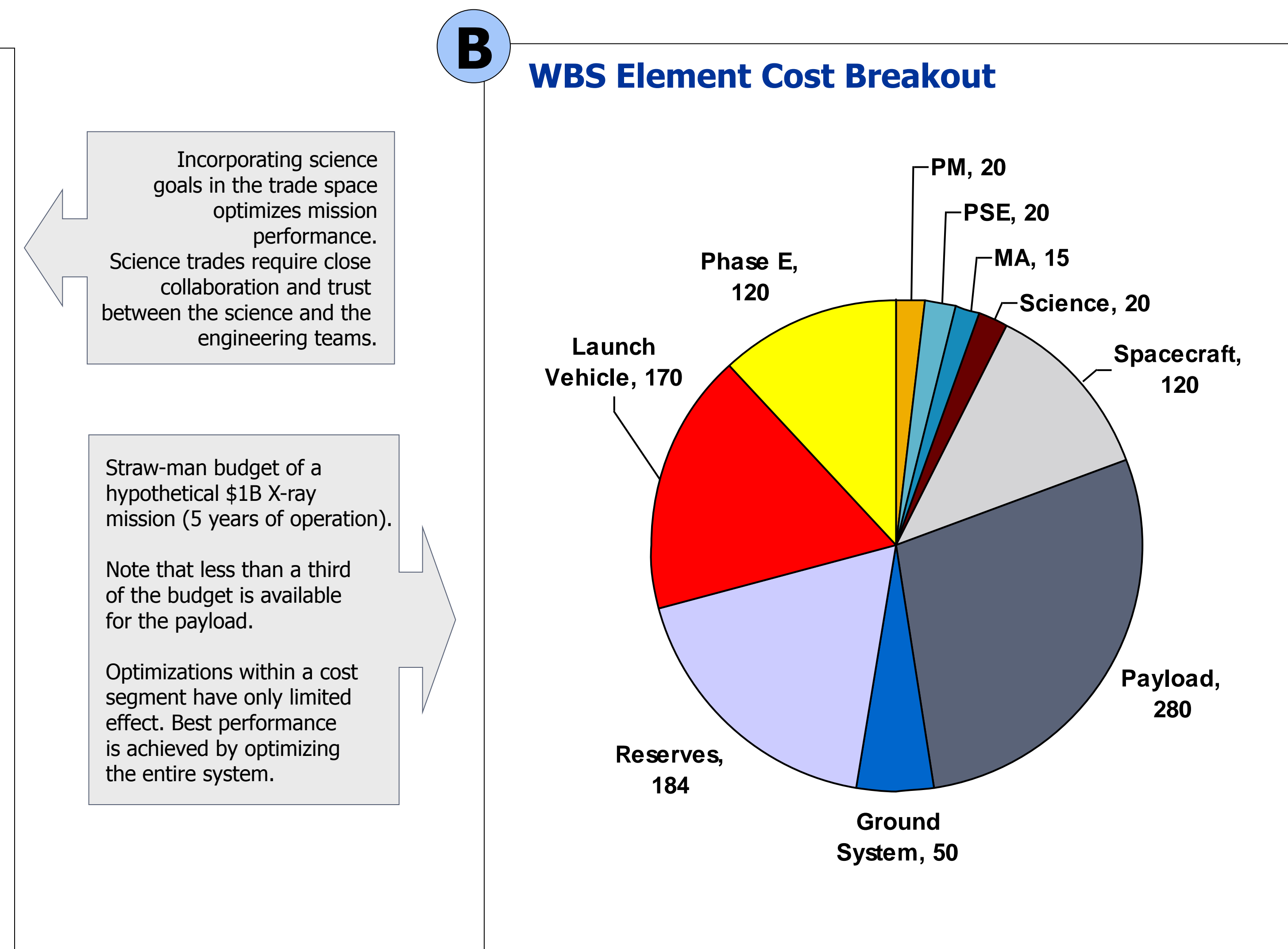
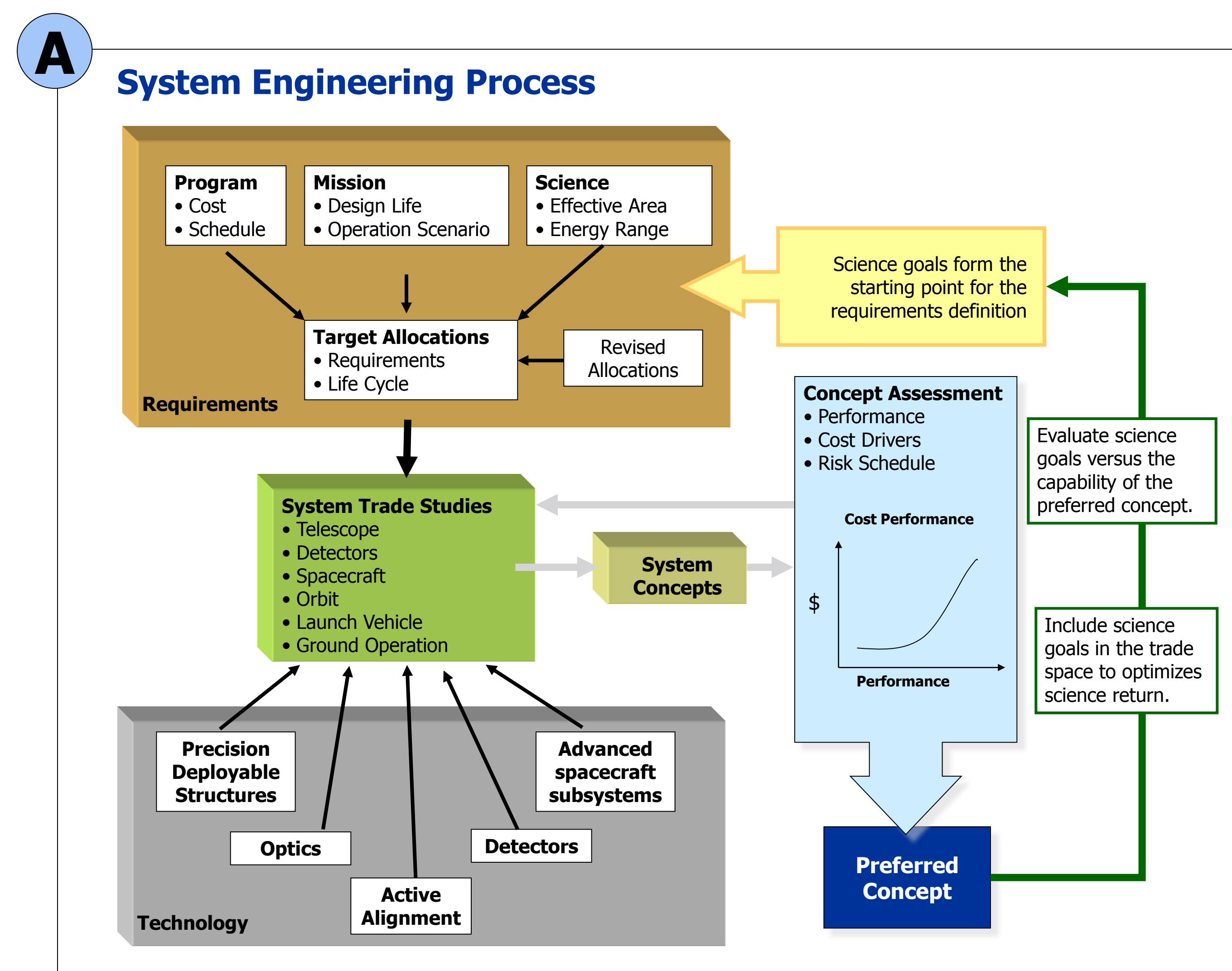
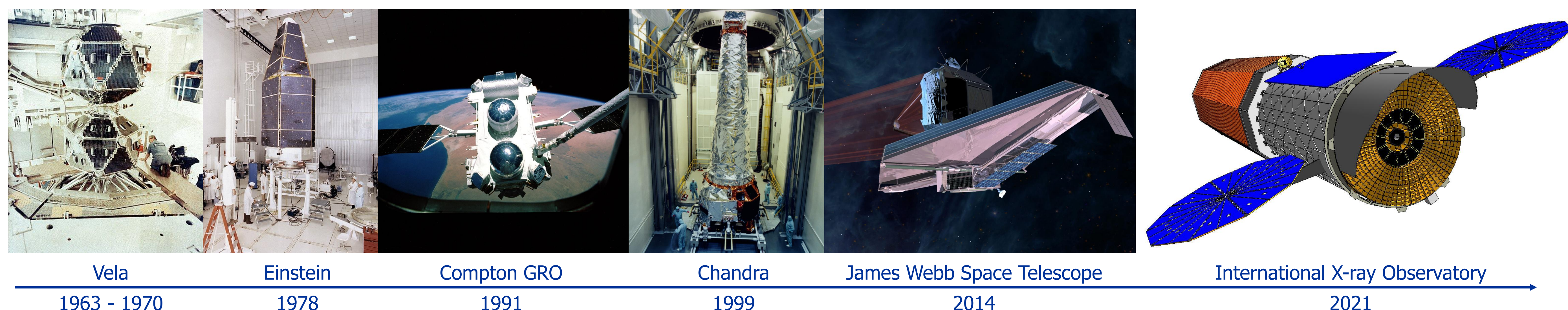
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## Abstract

Successfully developing and launching the International X-ray Observatory in a cost constrained environment will require a close partnership between scientists and engineers in academia, government and industry. We outline a development approach based on our experience of building the Chandra observatory that enables breakthrough scientific capability while maintaining credible commitment to tight cost constraints. Our approach further preserves flexibility in a changing funding environment and responsiveness to new technologies.

We begin with a framework for the system engineering process and argue that including science goals in the trade space is critical in achieving the best science performance. In this framework, scientists work side by side with engineers throughout the development optimizing the science return within the project's constraints and technical feasibility.

From the perspective of the builders of the Compton Gamma Ray Observatory, Chandra and the James Webb Spaces Telescope, we summarize our progress towards a robust yet flexible development model that will allow the International X-ray Observatory to move successfully from detailed concept studies to in-orbit science operation.



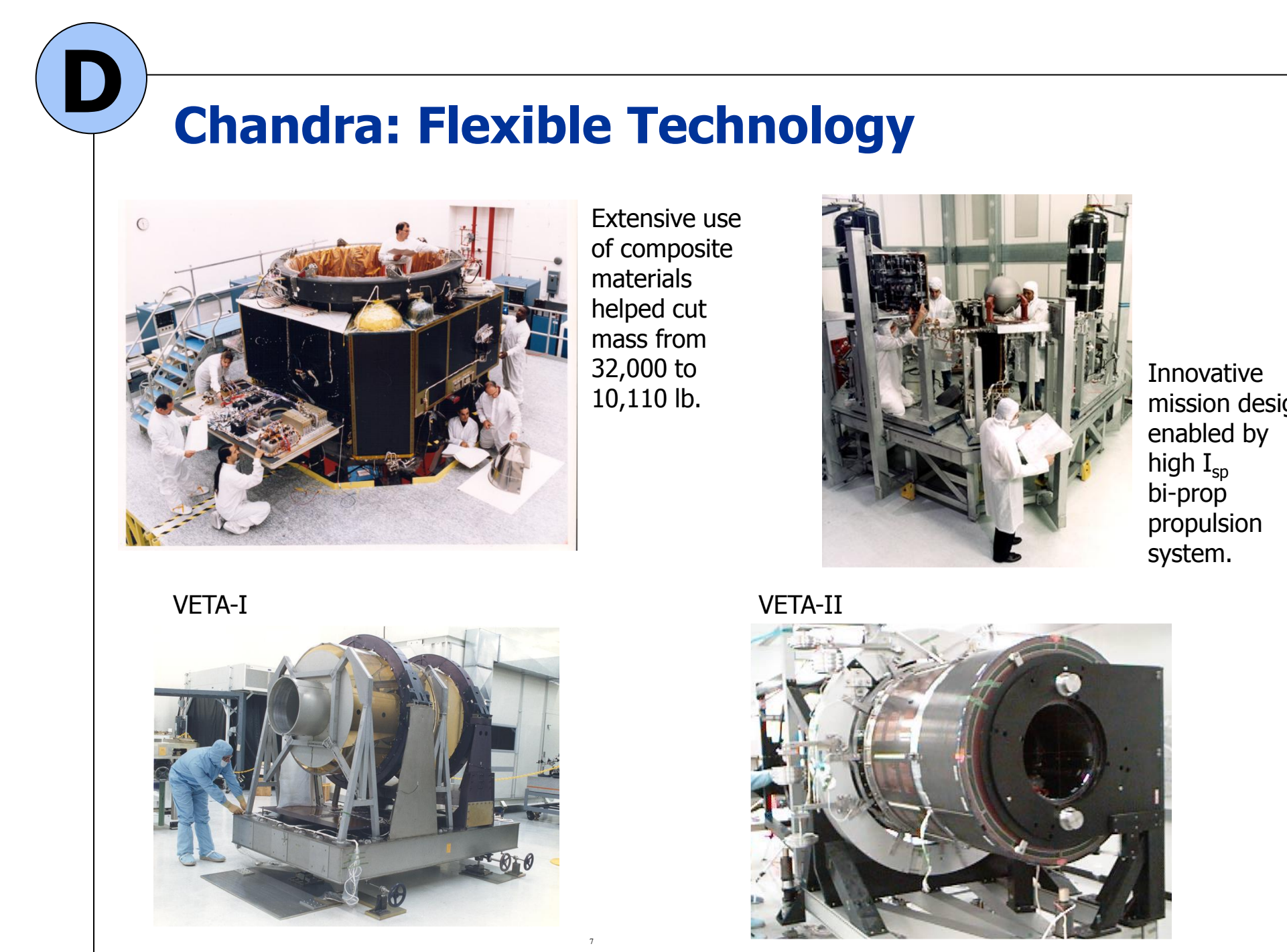
The science goal of extended energy range touches all elements of the observatory. A meaningful optimization can only be reached through the cooperation of all subsystems.

In 1992, in response to cost pressure, an integrated team re-planned the complete AXAF (now Chandra) mission in just under 4 months.

As a result, Chandra completed it's prime mission for billions of dollars less than originally planned.

K. Heifner & G. Davidson, AIAA-2004-5935 Space 2004 Conference and Exhibit, San Diego, California, Sep. 28-30, 2004

- ### E Chandra Implementation Approach
- Program management - team understood system drivers and constraints, and focused on mitigating the key risks.
  - Culture - influenced individual, organizational and team behavior to focus efforts on what was best for the program.
- ### Origins of Chandra's High Performance Culture
- NASA Project Office selected team members and assigned roles based on best value to the program,
    - Led by example in managing the broad team in a collaborative and constructive fashion.
  - Experienced science team that was fully integrated into the Project.
    - Science culture of skeptical inquiry and focus on ultimate mission utility was a core part of the overall Chandra culture.
  - Industry team was led by a prime contractor with the responsibility for aligning corporate incentives and behavior in accordance with program goals.



We have begun to explore trades with the potential to enhance the science performance of IXO without increasing the existing mass or cost envelope. Our emphasis at this stage is on system wide trades. While Chandra has demonstrated that even dramatic changes are possible late in the design life, early trades are key to avoiding unnecessary cost.

## Conclusion

Close and early collaboration between the scientific community, sponsoring organizations, industry partners and representatives of the public interest is the foundation for continued mission success and optimized science return within programmatic and technical constraints.

